The Swift GRB MIDEX Mission

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NASA-GSFC

Swift PI

SEUS Meeting September 24, 2003

Recent Swift Development

- Swift launch date recently slipped from Dec. '03 to May '04
- Launch date at selection in 1999 was Sept. '03
- Conflict with Messenger usage of thermal vac facility at GSFC and launch site at KSC could cause additional 1 month delay
- Recent slip due to development problems this summer with main gamma-ray telescope (Burst Alert Telescope - BAT)
  - Harness modification/replacement required to solve communication timing issue between processor and detector electronics (multiplex of 32,000 detectors)
- BAT is now complete. Other 2 instruments already on s/c.
- Spacecraft and 3 instruments uncompromised. Performance meets all specifications in 1999 proposal

Swift Hardware Teams and Partners

GSFC

PENNSTATE 1855

OSSERVATORIO ASTRONOMICO DI BRERA

University of Leicester

asi agenzia spaziale italiana

UCL MSSL

Los Alamos NATIONAL LABORATORY

eV PRODUCTS

SwRI

SONOMA STATE UNIVERSITY LUX MENTIS • LUX ORBIS • 1960

SPECTRUMASTRO

SWALES AEROSPACE

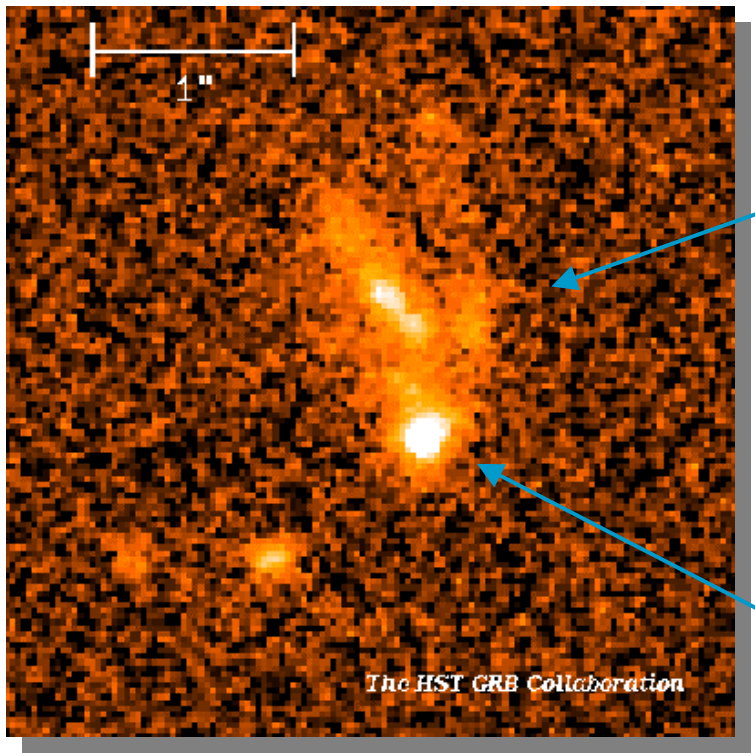
http://swift.gsfc.nasa.gov

OMITRON Inc.

Scientific Motivation for Swift

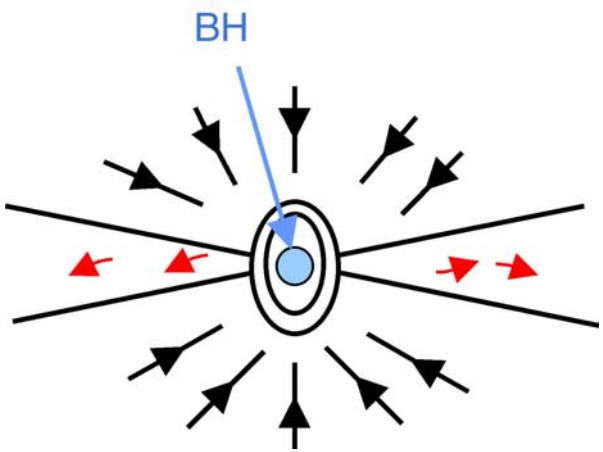
GRBs - The Ultimate SEU Phenomenon

- Most powerful explosions in Universe
- Birth sites of black holes
- Ultra-relativistic outflows
- Relation to hypernovae, end-points of massive stars and nucleosynthesis
- Probes of the early Universe

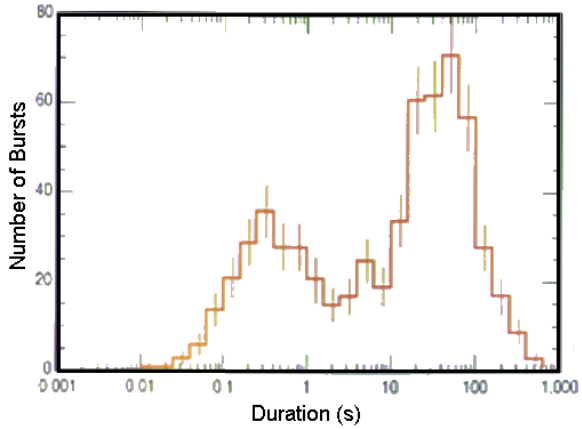


Swift Designed to Answer GRB Key Questions

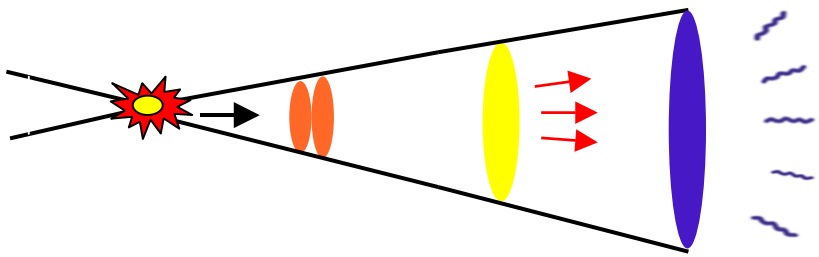
What causes GRBs?



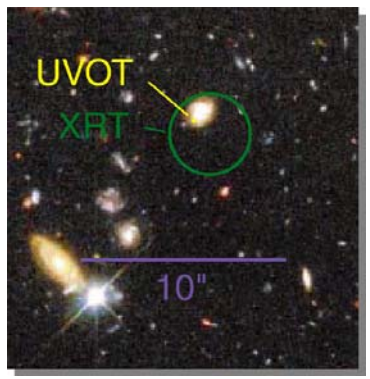
What is the nature of subclasses?



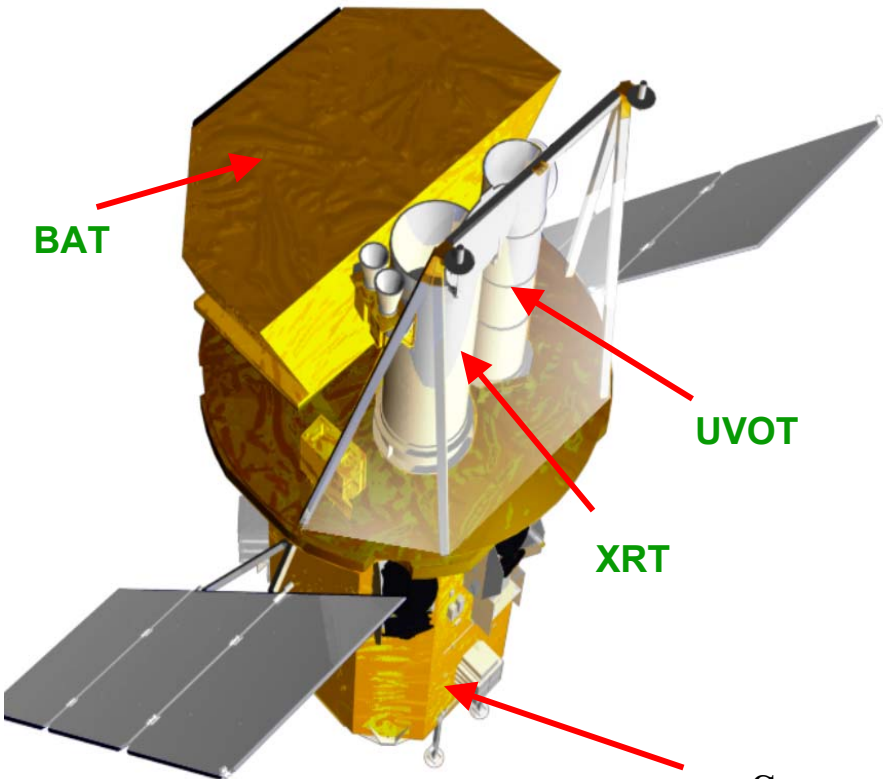
What physics can be learned about BH formation and ultra-relativistic outflows?



What can GRBs tell us about the early universe?



Swift Instruments



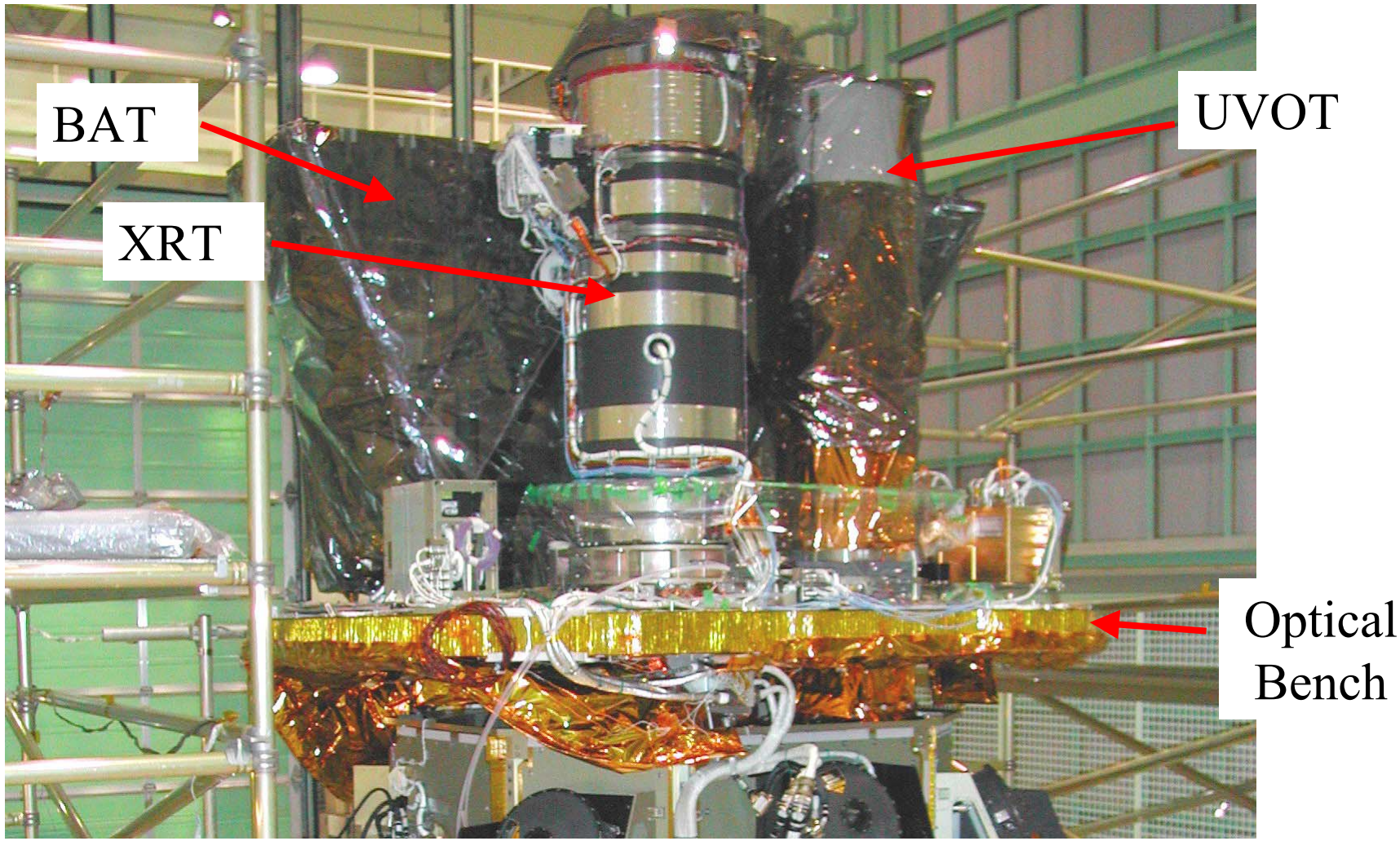
Instruments

- Burst Alert Telescope (BAT)
  - **New CdZnTe detectors**
  - **5200 cm^2**
- X-Ray Telescope (XRT)
  - **Arcsecond GRB positions**
  - **CCD spectroscopy**
- (UVOT) UV/Optical Telescope
  - **Sub-arcsec imaging**
  - **Grism spectroscopy**
  - **24^{th} mag sensitivity (1000 sec)**
  - **Finding chart for other observers**

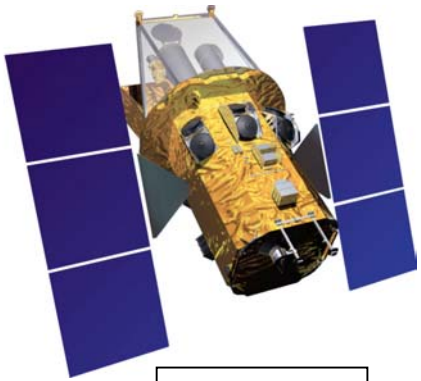
Spacecraft

- Autonomous re-pointing, 20 - 75 sec
- Onboard and ground triggers

The Actual Hardware



Swift Mission

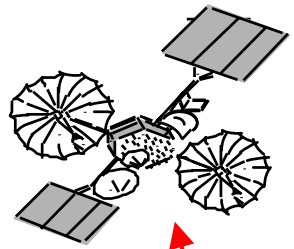


Spacecraft

Spectrum Astro
Rapid Autonomous Slews

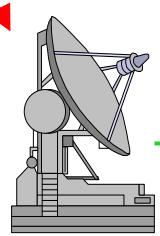
Payload

BAT
XRT
UVOT



TDRSS

Malindi



Mission Operations Center (MOC)

PSU

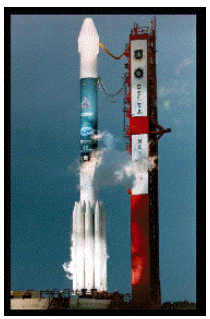
Science Center

GSFC

GCN & Web

HEASARC
UK
Italian
Archives

User Community



Launcher

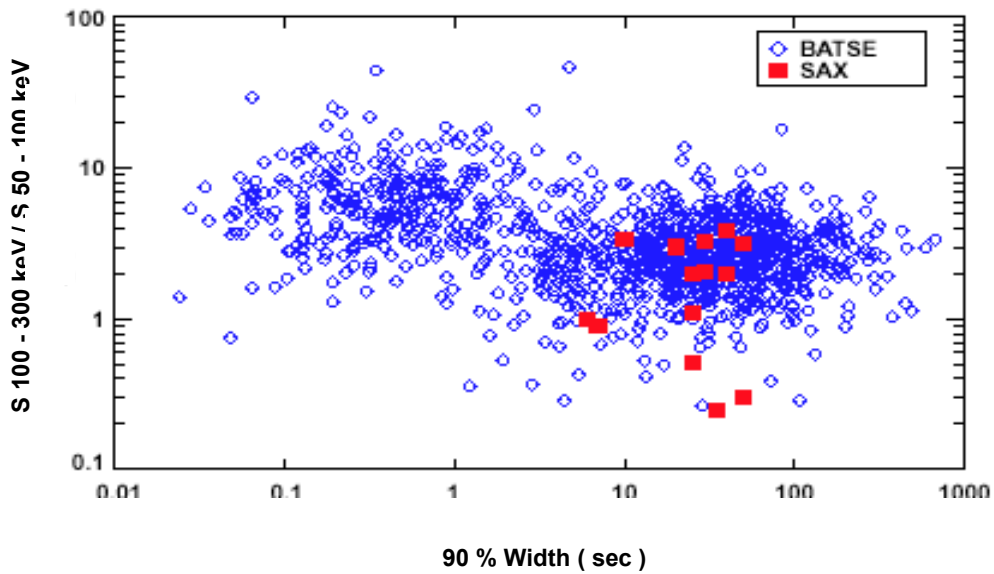
Delta 2320
600 km X 22^{o} inclination

Mission Capabilities

- Multiwavelength follow-up observations starting in 1 min. and continuing for days
- >100 GRBs per year by BAT with rapid localizations
  - Recent simulations give 300 GRBs triggers and 170 localizations per year
  - Approximately 20% of Swift GRBs will be short/hard bursts
  - Several per year X-ray flashes and X-ray rich bursts
- BAT sensitivity factor of 2 to 5 better than BATSE
- Nominal mission lifetime of 2 years, with orbital lifetime of ~8 years
- Upload capability to slew to GRB and transients detected by other observatories
- Arcsec positions and counterparts for 100's of GRBs
- Identification of host galaxies and measurement of offsets
- Multiwavelength observations on all timescales
- X-ray and UV/optical spectroscopy
- Rapid GRB notifications via GCN

Swift Science (1)

- Short GRBs
  - Not understood. No counterparts detected.
  - Appear to be a separate class. May have different physical origin.
  - Non-detection of afterglow for GRB 020531 indicates that afterglow is weak or rapidly declining.
  - Swift will perform rapid follow-up observations of ~100 short GRBs and solve this mystery.

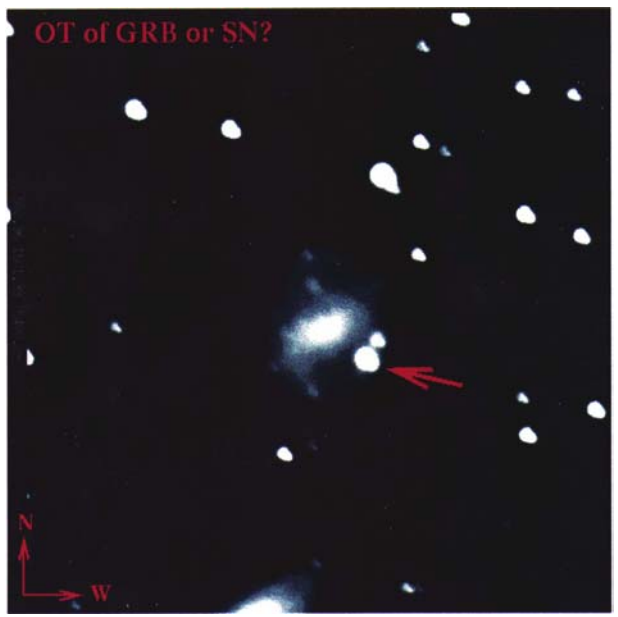


Djorgovski et al. (2001)

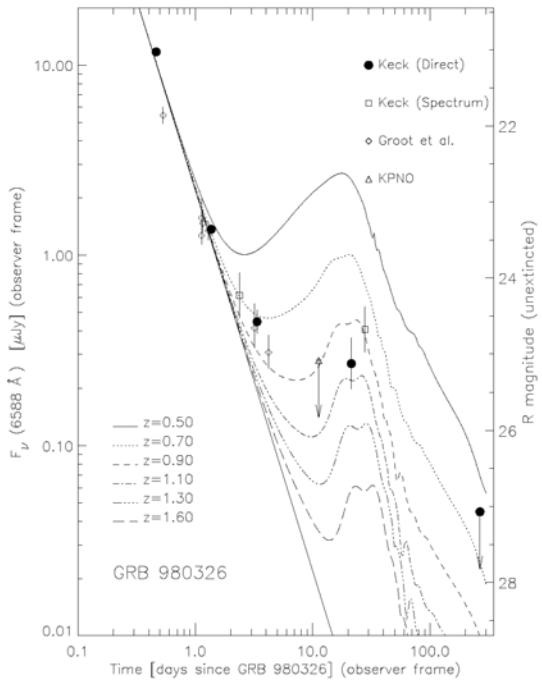
Swift Science (2)

- Supernova-GRB connection
  - Connections between SNe Ic and GRB are emerging.
  - GRBs are contributing to fundamental understanding of
    core collapse, BH formation, the role of spin in stellar evolution, origin of jets and origin of elements
  - Swift's rapid subarcsec positions and lightcurve monitoring will allow SN searches on 100's GRBs.
    Questions addressed: What fraction and what kinds of GRBs have underlying SN?
  - Searches for X-ray lines from GRBs will probe the circumstellar environment to determine pre-explosion history.

SN1998bw - GRB 980425

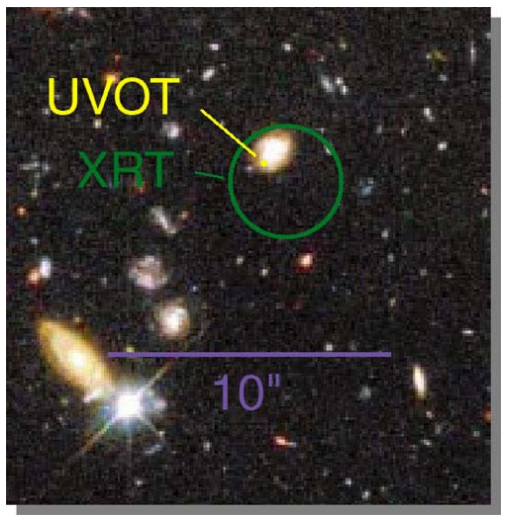


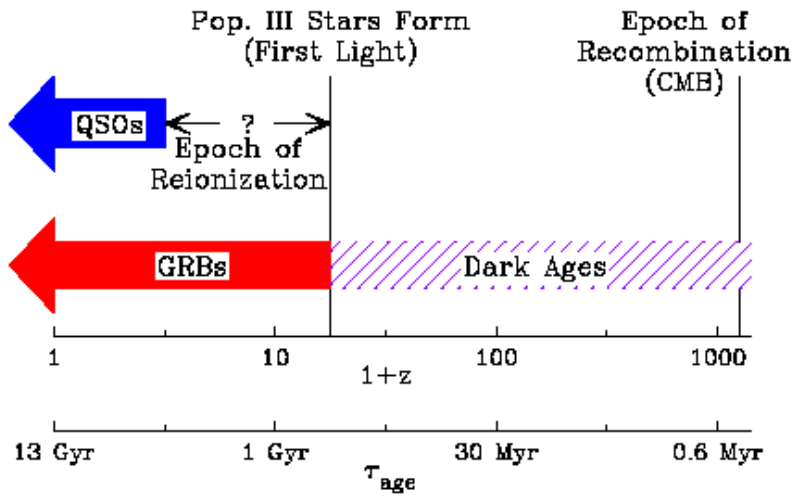
GRB 980326



Swift Science (3)

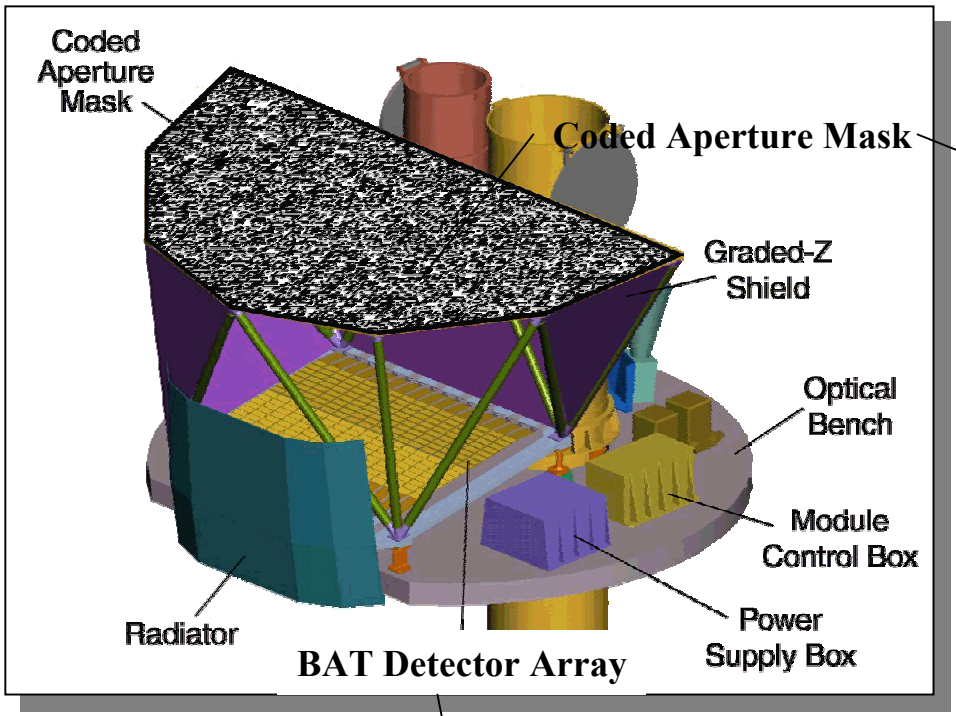
- Early Universe
  - GRBs are the brightest events in universe.
  - Afterglow is detectable to z~15 by Swift (3 to15 per year at z>10)
  - Topics addressed:
    - Epoch of first stars (GRB may be unique probe of PopIII stars)
    - Star formation history
    - Re-ionization of IGM z = 17 +/- 5 (Spergel et al. 2003)
    - Metallicity history
    - Dust and gas content of early galaxies
    - Large-scale structure of universe

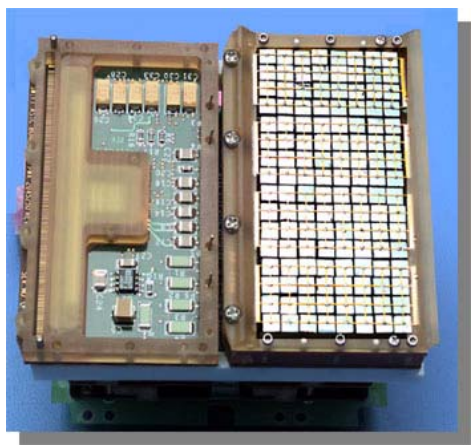




Lamb & Reichart (2000)

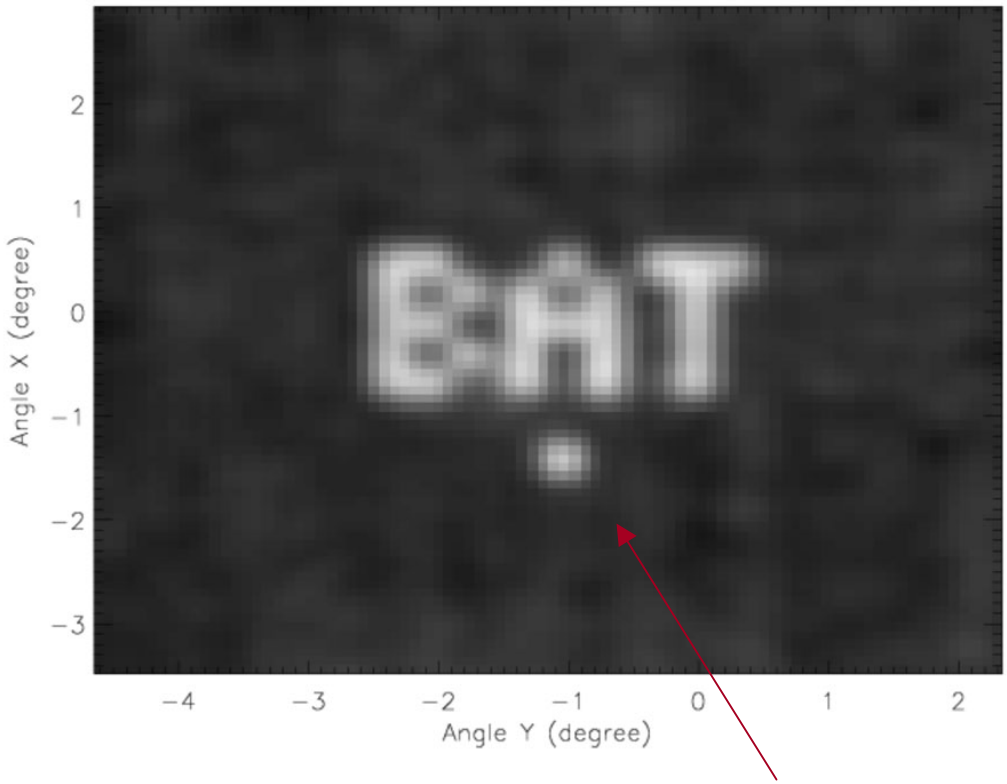
Burst Alert Telescope (BAT)





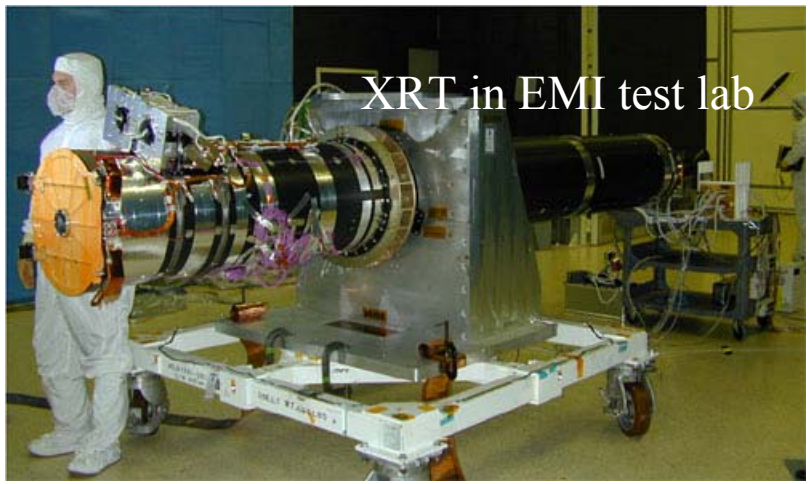
BAT Characteristics

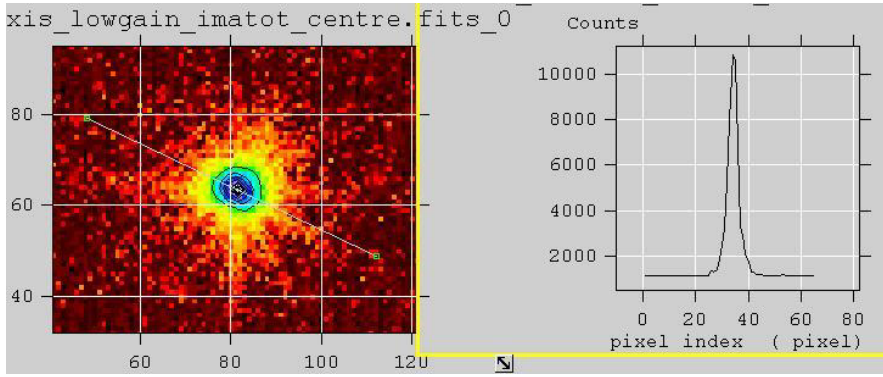
Telescope	Coded Aperture
Telescope PSF	17 arcmin FWHM
Position Accuracy	1-4 arcminutes
Detector	CZT
Detector Format	32768 pixels
Energy Resolution	7 keV FWHM (ave.)
Timing Resolution	100 microseconds
Field of View	2 Steradians, partially-coded
Energy Range	15 – 150 keV
Detector Area	5200 cm^2
Sensitivity	0.2 photons/cm^2/s
Max Flux	195,000 cps (entire array)
Operation	Autonomous

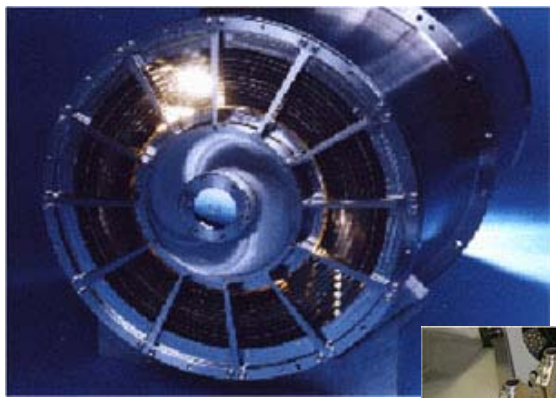


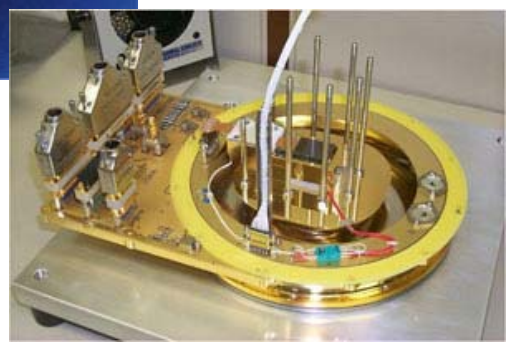
17 arcmin PSF

X-ray Telescope (XRT)







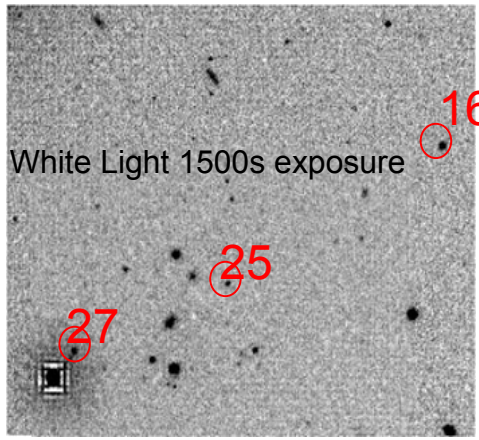


XRT Characteristics

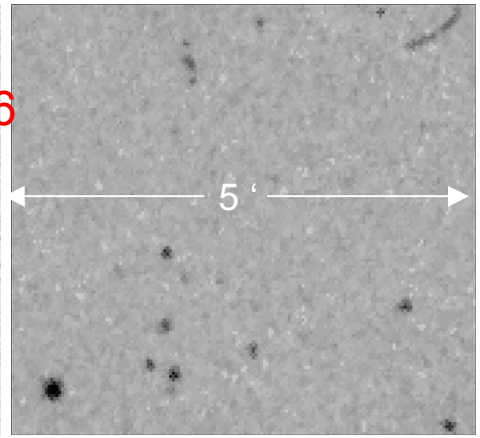
Telescope	3.5 m Wolter I, 12 shells
Telescope PSF	18 arcsec HPD @ 1.5 keV
Position Accuracy	2.5 arcsec (2 sigma)
Detector	E2V CCD-22
Detector Format	600 x 600 pixels
Energy Resolution	140 eV @ 5.9 keV
Timing Resolution	0.14 / 1.1 milliseconds
Field of View	23.6 x 23.6 arcmin
Pixel Scale	2.36 arcsec / pixel
Energy Range	0.2 - 10 keV
Effective Area	110 cm^2@ 1.5 keV
Sensitivity	$2x10^{-14}$ erg $cm^{-2}s^{-1}$ in $2x10^4$ s
Max Flux	> 45 Crabs (45,000 cps)
Operation	Autonomous

UV/Optical Telescope (UVOT)

XMM-OM

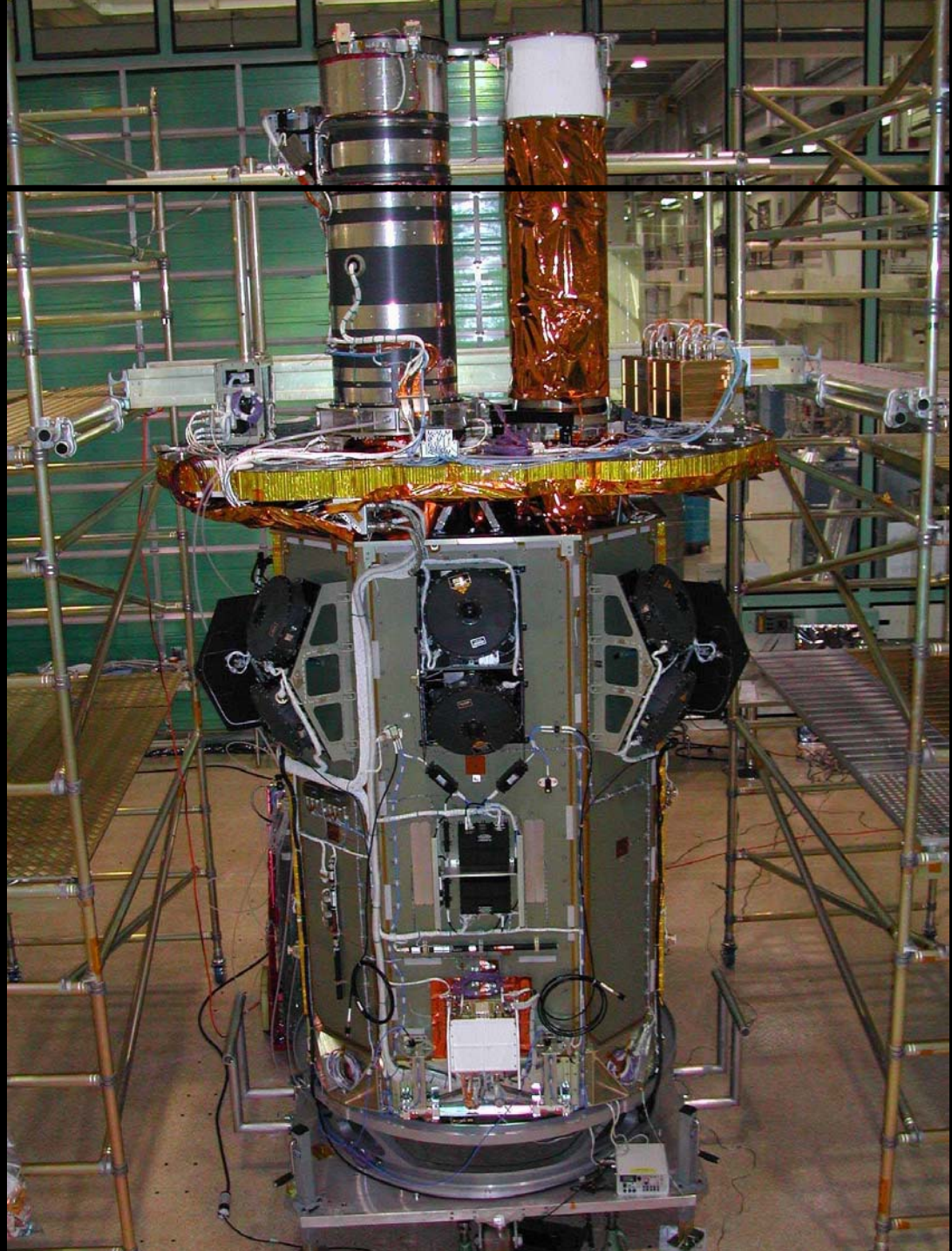


Digital Sky Survey



UVOT Characteristics

Telescope	30 cm Ritchie-Cretien
Telescope PSF	0.9 arcsec FWHM @ 350 nm
Position Accuracy	0.3 arcseconds (2 sigma)
Detector	Microchannel-intensified CCD
Detector Format	2048 x 2048 pixels
Spectral Resolutn	>300 @ 300 nm for $M_v < 17$
Timing Resolution	11 milliseconds
Field of View	17 x 17 arcminutes
Pixel Scale	0.5 arcsec / pixel
Spectral Range	170 – 600 nm
Sensitivity	24th magnitude in 1000 s
Max source	8th magnitude
Operation	Autonomous



Swift Status (1)

- Spacecraft and instruments all at Goddard
- Spacecraft delivered in June 2002
- XRT and UVOT delivered in Nov.-Dec. 2002
- Full environmental test program completed on XRT/UVOT
- XRT, UVOT and sunshield mounted on optical bench
- BAT fabrication complete in September 2003
- BAT EMI test last week and thermal vac test next week
- BAT delivery to S/C planned for November 2003
- Observatory environmental testing Nov. '03 - Mar. '04
- Observatory shipment to KSC planned for late March 2004
- Launch planned for May 2004

Swift Status (2)

- Observatory testing and science simulations underway
  - Malindi ground station (ASI) & ground network tests (including USN & back-up MOC)
  - Launch and early orbit "proc" tests - Sim#1a complete
  - 1000 GRB sims at LANL showing promising results
- Funding in place in UK and Italy for post-launch support
- On-board and ground software largely complete (through build ~4 out of 6)
- Data plans (including PDMP) to be presented to SAWG on Oct. 27

Recent Meetings

- Scientific Meetings
  - AAS Nashville May 2003 (Swift Topical Session)
  - Santorini, Budapest August 2003
  - Sante Fe September 2003
- Swift science team meetings every 4 months
  - GRB experts from outside team invited to give advice
- Programmatic Meetings
  - Anne Kinney meeting September 3, 2003
  - Explorer Retreat September 30 - October 1, 2003
- "Burst Advocate" workshop held at PSU Sept. 22-23, 2003

Swift Data Dissemination

- Rapid dissemination of burst positions and data to the world community via GCN and WWW. All data to everyone immediately.
- Triggers provided for ground and space telescopes: radio, IR, optical, x-ray, TeV, robotic, neutrino, gravitational wave, ...
- Follow-up team coordinated by Kevin Hurley
- Swift GI Program
  - Opportunities in Cycle 1
    - Correlative observations of GRBs with non-Swift instruments and observatories
    - New GRB projects using Swift data but not requiring GI-specified observatory pointings
    - Theoretical investigations that advance the mission science return in the area of GRBs
  - $1M in grants to be awarded for cycle 1
  - 67 Notices of Intent received
  - Proposals due Dec. 1

Swift EPO Program

Led by Lynn Cominsky (Sonoma State University)